Online Visualization and Value Added Services of MERRA-2 Data at GES DISC

5th Reanalysis
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https://disc.gsfc.nasa.gov NASA/Goddard EARTH SCIENCES DATA and INFORMATION SERVICES CENTER (GES DISC)

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NASA climate reanalysis datasets from MERRA-2, distributed at the Goddard Earth Sciences Data and Information Services Center (GES DISC), have been used in broad research areas, such as climate variations, extreme weather, agriculture, renewable energy, and air quality, etc. The datasets contain numerous variables for atmosphere, land, and ocean, grouped into 95 products. The total archived volume is ~ 337 TB (~ 562K files) at the end of October 2017. Due to the large number of products and files, and large data volumes, it may be a challenge for a user to find and download the data of interest. The support team at GES DISC, working closely with the MERRA-2 science team, has created and is continuing to work on value added data services to best meet the needs of a broad user community .

This presentation, using aerosol over Asia Monsoon as an example, provides an overview of the MERRA-2 data services at GES DISC, including:

- How to find the data? How many data access methods are provided? What are the best data access methods for me?
- How do download the subsetted (parameter, spatial, temporal) data and save in preferred spatial resolution and data format ?
- How to visualize and explore the data online ?

In addition, we introduce a future online analytic tool designed for supporting application research, focusing on long-term hourly time-series data access and analysis.

Basic Data and Distribution Information:

https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/docs/

- **Temporal Coverage:** 1980-present
- **Temporal Resolution:** Hourly, 3-hourly, Monthly, Monthly diurnal
- **Spatial Coverage:** Global
- **Spatial Resolution:** 0.5° x 0.625°
- **Number of Product Groups:** 95
- **Data Format:** NetCDF-4

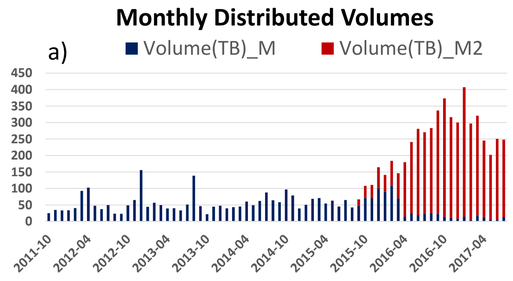


Fig.1: a) Monthly distribution volumes for MERRA (black) and MERRA-2 (red) ; b) Top 15 popular products in terms of users. (Names underlined in red are monthly products)

Example Analysis with Giovanni

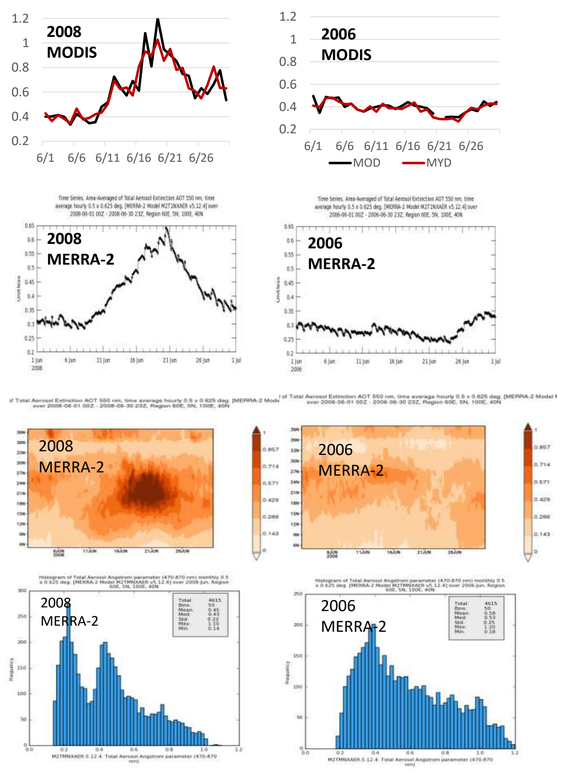


Fig. 4: From upper to lower images: MODIS daily time series of AOT 550nm, MERRA-2 hourly time series of AOT 550nm, MERRA-2 latitude-time cross section map of AOT 550nm, and MERRA-2 distribution of Angstrom (470-870 nm). In this example, the aerosol load in June 2008 is much higher than that in June 2006, and the size distribution is noticeably different.

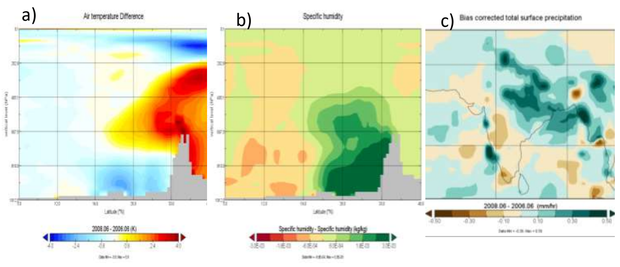
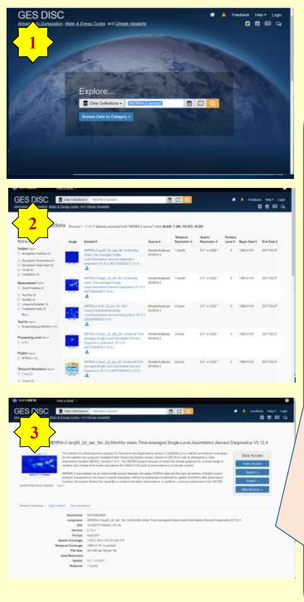


Fig. 5: Monthly differences in June between 2008 and 2006 for a) Temperature vertical cross-section averaged 75°E-85°E, b) Specific humidity vertical cross-section averaged 75°E-85°E, c) Bias corrected total precipitation. In 2008, the large aerosol load year, the precipitation over northern Indian is higher, which is associated with higher temperatures over the Tibetan plateau and higher specific humidity at south of Tibetan plateau. Results are consistent to the study in [2].

***Note** that In this example, the monthly data were saved from Giovanni, then imported into Panoply to calculate difference and generate plots.*

Finding Data

GES DISC Data Search System
http://disc.gsfc.nasa.gov/datasets?keywords="MERRA-2"



11 aerosol products

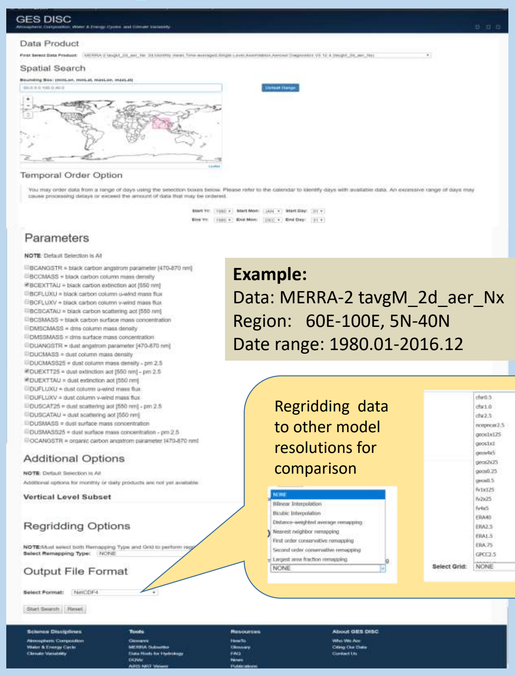
The product landing page contains:

- **Product Summary**
- **Documentation**
  - ✓ User's guide
  - ✓ File specific
  - ✓ Key references
  - ✓ Tools
- **Data Citation:**
  Cite the dataset in publications e.g: Global Modeling and Assimilation Office (GMAO)(2015), MERRA-2 tavgM_2d_aer_Nx: 2d,Monthly mean,Time-averaged, Single-Level, Assimilation, Aerosol Diagnostics V5.12.4, Greenbelt, MD, USA, Goddard Earth Sciences Data and Information Services Center (GES DISC), Accessed ***[Data Access Date]*** 10.5067/FH9A0MLJPC7N

Data Access Methods:

- ✓ MERRA-2 subsetter
- ✓ Direct download (HTTPS)
- ✓ OPeNDAP
- ✓ GDS
- ✓ Giovanni: visualization
- ✓ Data Recipes (step-by-step instructions on accessing, reading, & viewing data with various data tools)

Getting Subsetted Data



Example:
Data: MERRA-2 tavgM_2d_aer_Nx
Region: 60E-100E, 5N-40N
Date range: 1980.01-2016.12

Key Features:

- Subset option: spatial, parameter, time
- Preprocessing option: daily mean for hourly product, regridding to other model resolutions (~ 30 models)
- Output format option: NetCDF-4, NetCDF-classic, HDF-EOS2 (same as MERRA)

To download time series data at a single point, please read:
How to Obtain Spatial Subsetted Time Series in ASCII Format Via GDS

Example of Aerosols over Indian Monsoon Region:

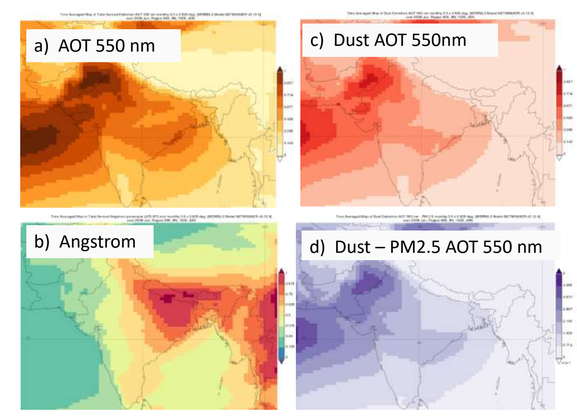


Fig. 2 Sample images of monthly (June 2008) aerosol variables over Indian Monsoon region for a) Total aerosol extinction AOT at 550nm, b) Total aerosol angstrom (470-870 nm), c) Dust extinction AOT 550nm, d) Dust extinction AOT 550 nm – pm 2.5.

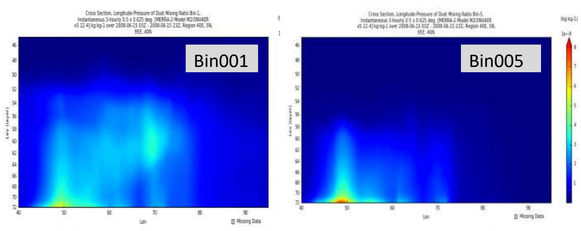
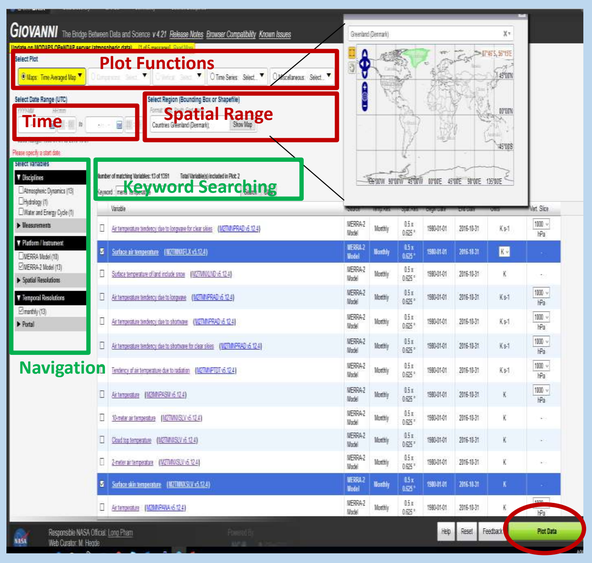


Fig. 3 Sample images of vertical cross-section map of 3-hourly (Jun 15, 2008) dust mixing ratio averaged over 5°N-40°N, indicating that smaller sized dust particles went much higher and traveled farther than the larger sized particles.

MERRA-2 dust mass-mixing ratio of particles are in five bins with the size ranges: 0.1--1, 1--1.8, 1.8--3, 3--6, 6--10 (radius is in μm) [1]

Visualization



Single Parameter :

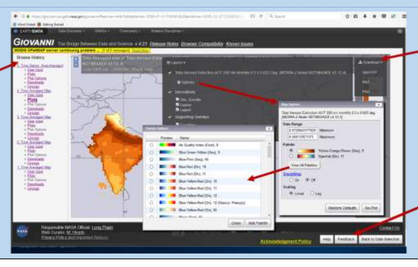
- Lat–Lon map of time-averaged data
- **Map of a shaped region, such as country, watershed** ★
- Time-series of bounding box area-averaged data
- **Time-series of a shaped area-averaged data (country or watershed)** ★
- Hovmöller diagram/cross section map
- Histogram
- Vertical profile, cross-section map
- Zonal mean
- Animations of Lat–Lon map over time
- Multi-year monthly averaged
- Interannual monthly or seasonal mean
- Calculate accumulation (such as precipitation)

Multi-parameters:

- Scatter plots with regression statistics
- Temporal correlation maps
- Lat–Lon map overlain with 2nd parameter contour plot
- Time-series differences
- Lat–Lon map differences
- Regridding (for different spatial resolutions)

Output Features:

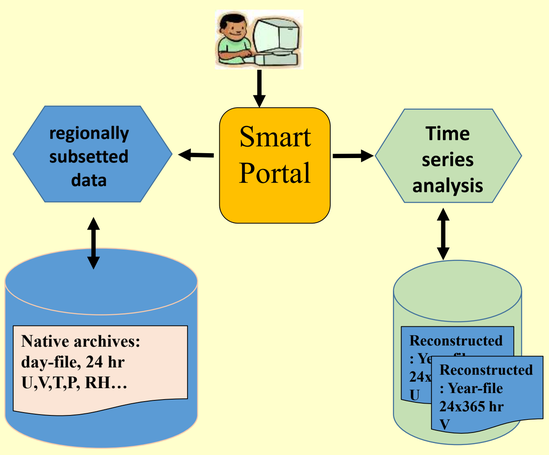
- Image: PNG, Geotiff, and KMZ
- Data: NetCDF, ASCII
- Provides WMS and WCS to other Web servers to get maps or data from Giovanni



A Future Service

Long-term Time Series Access and Analytic Tool for Application Users

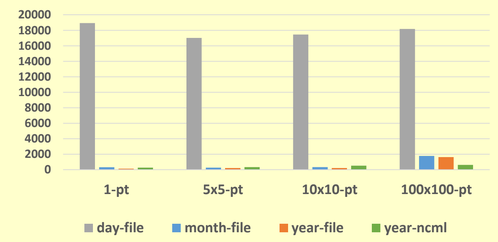
- ✓ Downloading time series at a single point or a small area into a single file in different data format (e.g.: ASCII, NetCDF, or flat binary) easy and fast;
- ✓ Computing basic statistics, for example, mean, minimum, maximum, and standard deviation, etc. ;
- ✓ Finding extreme events, such as days of very windy, hot or cold, drought, and high aerosol load, etc.



Technique approach:

- Reconstructing data files
- Creating value added datasets for a specific applications
- Integrating selected data into cloud environment
- Packaging data based on application areas
- Creating How-to documents

Performance Tests of Accessing Reconstructed Data



Time (unit=sec) to download **10-year data** into a single file with **wget** method from OPeNDAP for different data cubes to extract array sizes: 1x1, 5x5, 10x10, and 100x100

day-file: native archived file (current)
month-file: reconstructed data cube
year-file: reconstructed data cube
year-ncml: ncml virtual time aggregated

Example Hourly Wind Speed at 50m

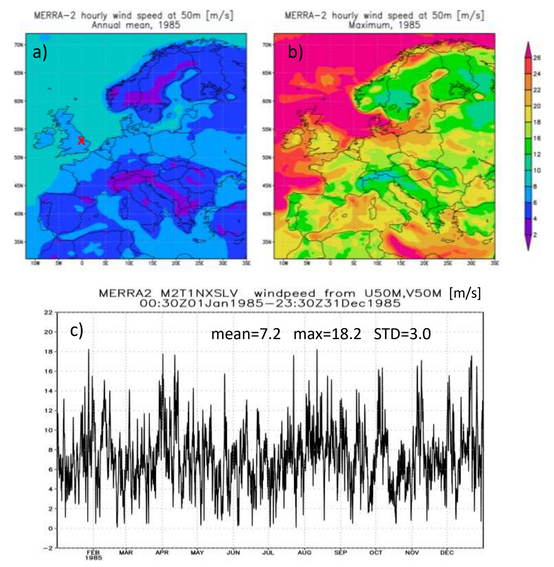


Fig. 6: Examples of hourly wind speed at 50m [m/s] above surface over Europe for a) 1985 annual mean, b) 1985 maximum, c) time series at location marked as **X** in a)

Example of Root Zone Soil Water Anomaly during a California Drought

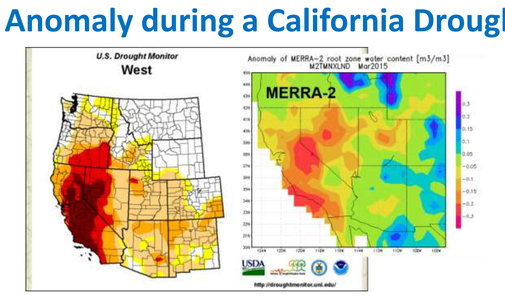


Fig. 7: Weekly drought index beginning 3 March 2015 (left, map *courtesy of NDMC-UNL* http://droughtmonitor.unl.edu) [3] and Monthly MERRA-2 root zone soil water (right) of March 2015

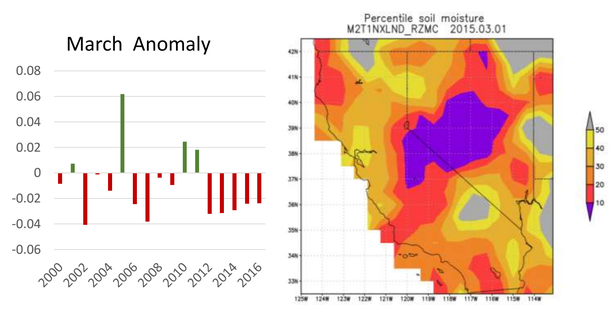


Fig. 8: Monthly root zone water anomaly of March from 2000 to 2016 (left); and example of percentiles map of root zone water on 1 March 2015 (right), calculated by using hourly data. The climatology base period used is 1980.01.01 to 2014.12.31

Should you have questions and feedback about the MERRA-2 data and/or services, please send to:
merra-questions@lists.nasa.gov for science and MERRA-2 system
gsfc-help-disc@lists.nasa.gov for data access

References:
[1] *Colarco, P., A. da Silva, M. Chin, and T. Diehl (2010), Online simulations of global aerosol distributions in the NASA GEOS-4 model and comparisons to satellite and ground-based aerosol optical depth, J. Geophys. Res., 115, D14207, doi:10.1029/2009JD012820*
[2] Lau, W.K.M., Kim, KM., Shi, JJ. et al. Clim Dyn (2017) 49: 1945. https://doi.org/10.1007/s00382-016-3430-y Impacts of aerosol–monsoon interaction on rainfall and circulation over Northern India and the Himalaya Foothills
[3] *The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Map courtesy of NDMC-UNL.* http://droughtmonitor.unl.edu